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TRANSVERSE STRENGTH EVALUATION OF LIGHT CURED RESIN IMPREGNATED FIBER GLASS REINFORCED COMPLETE DENTURE

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ABSTRACT

Background: The transverse strength of heat-polymerized denture base resins considerably enhanced by including either metal wires or glass fibers. Moreover, the transverse strength of specimens reinforced with continuous unidirectional glass fibers was significantly higher than that of metal wire or woven fiber reinforcements. **Materials and Methods:** Acrylic resin specimens had divided into two groups according to the type of material tested (group I: conventional heat cured acrylic resin, group II: resin impregnated fiberglass reinforced complete denture base). Static load on the prepared specimen using universal testing machine. Three points bending apparatus used to position the specimens with 7.5 KN load on each specimen. The three-point bending apparatus consisted of two parallel stainless steel rods away from each other by 50 mm. While the 7.5 KN load was applied centrally by a 10 mm diameter cylindrical stainless steel rod with 5 mm/min speed. **Results:** The transverse strength values of resin impregnated fiberglass reinforced acrylic resin showed statistically significant higher values (as $P < 0.05$) than conventional heat cured acrylic resin. **Conclusion:** that Fibers critical length was a measure of minimum fiber length required for maximum stress transfer within polymer matrix. Working with bisGMA resin, the critical fiber length established for acrylics with increased values.

Key words: Transeverse, Fiber, Reinforce, Denture.

INTRODUCTION

One of the commonly used denture base materials that have dominated in the prosthetic appliances was the polymethyl methacrylate denture base material. It is involved in complete and partial dentures, it extends to involve different, and multiple aspects of prosthetic work [1].

The polymethyl methacrylate is not ideal in every aspect as a denture base material. It is the combination of virtues rather than one single desirable property that accounts for its popularity and usage. Despite its popularity in satisfying esthetic demands it is still far from ideal in fulfilling the mechanical requirements of prosthesis[2].

The most commonly used material for complete denture fabrication is heat-cured polymethylmethacrylate (PMMA). Due to its low cost, ease of fabrication and polishing made the PMMA a preferred base material[3].

Flexural fatigue stress exerted due to repeated masticatory forces is one of the primary causes of PMMA resin denture base fractures. Majority of PMMA resin dentures fracture at the end of three years in service or gradually during function [4].

Several studies had investigated the incidence and types of denture fractures. It reported that 33% of repairs were carried out due to debonded / detached teeth and 29 % were repairs to midline

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fractures which more commonly seen in lower complete dentures. The midline fracture in a denture is often a result of flexural fatigue. Impact failures usually occurred due to sudden blow of the denture due to accidental dropping (5).

Fiber reinforced composites were universally used materials in aircraft and in space applications, in the marine and automotive industries, infrastructure and building construction and medical applications. They were made of plastic matrix that reinforced by fine thin fibers, which have high tensile strength and high flexural modulus. It also called fiber-reinforced polymer or glass reinforced plastic (6).

The polymeric plastic matrix, consisting of polymerized monomers, had the function of holding the fibers together in the composite structure. It also transfers stresses between fibers and protects the fibers from the outside environment such as chemicals, moisture and mechanical shocks (7).

Setting reactions in the resin matrix were polymerization reactions and crosslinking reactions. A polymerization reaction was the formation of a polymer by sequential addition of monomeric units. Typical polymerization reactions were addition and condensation polymerizations (8).

A fiber might described as an elongated uniform material with a more or less equiaxed and uniform transverse cross sectional diameter or thickness less than 250 μm, and with an aspect ratio, i.e length to cross-sectional diameter or thickness ration, which was usually greater than about 100 (9) .

The glass surface modifications by treatment with a coupling agent used to improve fiber/matrix interfacial strength through physical and chemical bonds, and to protect the fiber surface from environmental conditions, such as moisture and reactive fluids (10).

Denture bases typically fabricated from polymer (powder) and monomer (liquid) for form a multiphase acrylic resin by polymerization. Glass fibers could use in two ways to reinforce a multiphase denture base acrylic (11).

Flexure, transverse or modulus of rupture, as this property variously called, essentially a strength test of a bar supposed at each end, or a thin disk supposed along a lower support circle, under static load. For the disk specimen, the failure stress value referred to as the biaxial flexure strength (12).

The transverse strength of heat-polymerized denture base resins considerably enhanced by including either metal wires or glass fibers. Moreover, the flexural strength of specimens reinforced with continuous unidirectional glass fibers was significantly higher than that of metal wire or woven fiber reinforcements (13).

Researchers compared unreinforced and glass fiber-reinforced acrylic resin polymers prepared under both conventional heat curing and microwave curing techniques. Strengthening with the fibers decreased the flexural strength of the resins but increased flexural resistance. Thus when high impact resins were needed, fiber reinforced resins might be the material of choice (14).

MATERIALS AND METHODS

Total 120 specimens were preliminary designed and fabricated; 60 for each group. In each group 10 specimens were used to evaluate each mechanical property.

Following ADA specification NO.12, the following five metal patterns constructed for acrylic resin specimen’s preparation and milled using 3D milling machine with 3D image software.

Mold constructed throughout using metal flask of denture processing. Using standard three pour technique, the lower portion of the dental flask was filled with dental plaster mixed according to manufacturer`s instructions. Separating medium applied by a thin brush on the metal pattern. Then, a second layer of plaster mix coated on metal pattern to prevent entrapment of air during the pouring process. The third pour of dental plaster applied after setting of the second pour (30 min).

All the previous pours performed by using laboratory vibrator for assurance of no entrapment of air bubbles during mixing. Once the plaster and metal patterns were coated with separating medium, the upper half of the flask was tightened in place to assure metal to metal contact. Finally, the flask was carefully deflasked to avoid damaging of the mold, metal pattern removed and the mold obtained.

For group I, conventional non-reinforced heat cured acrylic resin was mixed and packed following the manufacturer`s instructions. Powder/Liquid of 3:1 by volume mixed with compatible inert metal spatula to avoid any unwanted retardation reactions and then kept in a sealed jar to reach desired dough stage.

The material packed into the plaster mold with excess material. Then, the metal flask was compressed with the hydraulic press under 100-150 bar to remove excess resin fins and to check any deficient material inside the mold as a trial packing. Placing into the water path for 30 minutes at 72 °C and extended for another 60 minutes at 100 °C for long cycle heat curing.

After curing, the flask removed from the water path and allowed to bench cool at room temperature. After deflasking, the specimens were finished and polished using rubber wheel stone to remove excess materials and to avoid distrubting measurements taken by ADA specification NO. 12.

For group II, a light cured resin impregnated fiberglass used as a reinforcement mesh for conventional heat cured acrylic resin specimens.

Before setting and application, a suitable size of the fiber meshwork cut according to the size of the used mold, adapted gently inside the mold, and fixed in place using light cured resin supplied by the manufacturer, figure (1).

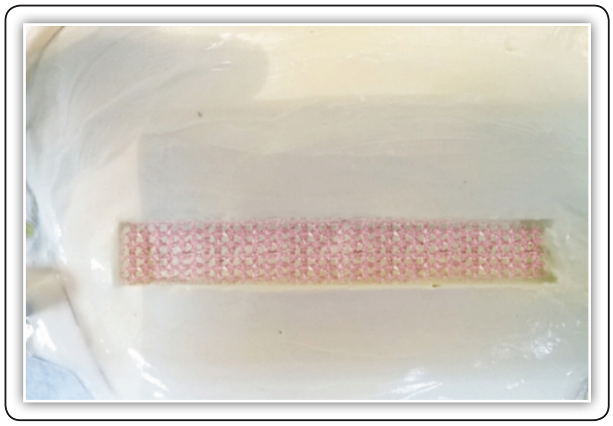

FIG (1)

Using LED light curing unit, the applied fiber meshwork cured by wavelength Using LED light curing unit, the applied fiber meshwork cured by wavelength ranged from 430 to 500 nm for a fixed definite time (at least two minutes). After complete curing, standard mix performed until reaching dough stage and pressurized using hydraulic press into the flask to obtain intimate mechanical interlocking between acrylic resin specimen and light cured fiber meshwork. Finishing and polishing performed using usual standards of group I.

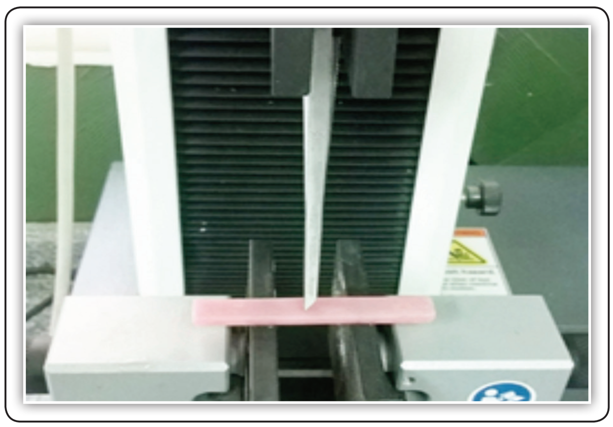

FIG (2)

Static load on the prepared specimen using universal tester. Three points bending apparatus used to position the specimens with 7.5 KN load on each specimen. The three-point bending apparatus consisted of two parallel stainless steel rods away from each other by 50 mm. While the 7.5 KN load was applied centrally by a 10 mm diameter cylindrical St. St. rod with 5 mm/min speed.

RESULTS

Transverse strength obtained using the following equation:

[$S = 3PI/2bd^2$] as **S**; Transverse strength (N/mm^2), **P**; Maximum force exerted on specimen (N), **I**; Distance between the supports (mm), **b**; Width of a specimen (mm) and **d**; Depth of a specimen (mm)

Mean ± SD values of transverse strength for conventional heat cured acrylic resin (group I) were (74.29 ± 2.04 MPa) while for resin impregnated fiberglass reinforced acrylic resin (group II) were (163.096 ± 1.84 MPa).

At level of probability $P \leq 0.05$, independent t-test was performed to evaluate the significance between both groups which revealed that there was significant difference between both groups as $P = 0.00 < 0.05$, table (1) and figure (3).

TABLE (1): Mean and standard deviation (SD) values of Transverse Strength (MPa) for comparison between Conventional Heat-Cured Acrylic Resin (Group I) and Resin Impregnated Fiber Glass Reinforced Acrylic Resin (Group II):

Mean ± SD	Conventional Heat-Cured Acrylic Resin (Group I)	Resin Impregnated Fiber Glass Reinforced Acrylic Resin (Group II)	P- value
Transverse Strength	2.04 MPa ± 74.29	163.096 ± 1.84 MPa	**0.00****

M; Mean,

SD; Standard Deviation,

P; Probability Level

***significant Difference*

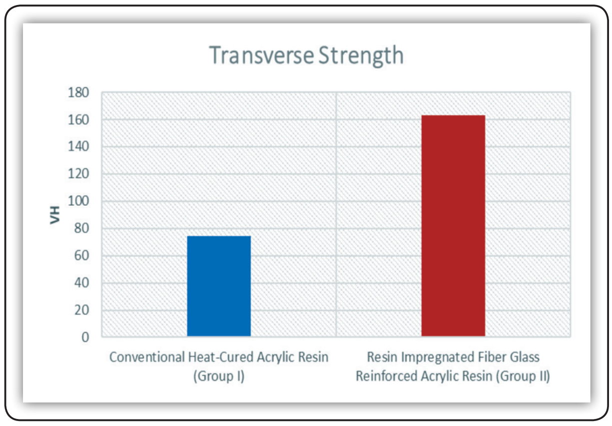

FIG (3)

DISCUSSION

In this consideration, the transverse (flexural) strength of the resin impregnated fiber glass reinforced acrylic resin denture base (163.096 ± 1.84 MPa) revealed significant higher value than the conventional one (74.29 ± 2.04 MPa). This might attributed to better micro mechanical interaction between fibers and acrylics. These results explained the increase in flexural strength was due to the silane coupling agent treatment increased fiber surface energy resulting in better impregnation by the polymer matrix [15].

The oxygen inside voids released during polymerization of acrylic resins and porosities can affect flexural properties in a higher degree. Increased flexural strength of fiberglass reinforced denture base could attributed to high temperature during resin polymerization, which created a condensed silane coupling to the fiber boundaries and thus increasing adhesion [13].

In addition, it concluded that fibers critical length was a measure of minimum fiber length required for maximum stress transfer within polymer matrix. Working with bisGMA resin, the critical fiber length established for acrylics with increased values. If a deterioration of adhesion between fibers took place, it would be necessary to increase the fiber critical length in order to achieve reliable mechanical properties [14].

CONCLUSION

Within the limitations regarding transverse strength study, the conventional heat cured denture base proved to lower than the resin impregnated light cured fiberglass reinforced one within certain limits.

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